Idaho Incubation Fund Program

Progress Report Form

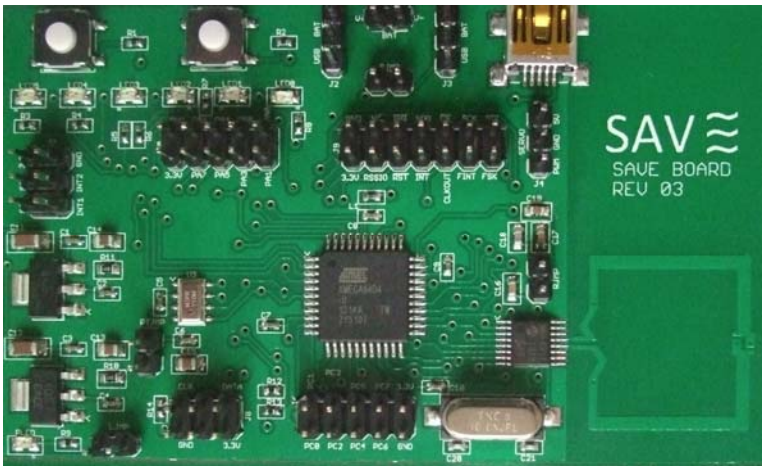
Proposal No.	**IF14-008**
Name:	**Gang-Ryung Uh**
Name of Institution:	**Boise State University**
Project Title:	**Self-organizing Air VEnt (SAVE) System**
Reporting Period:	**Till May 30th, 2014**

Information to be reported in your progress report is as follows (attach additional information as needed):

1. Summary of project accomplishments for the period just completed and plans for the coming reporting period:

Electrical/Firmware:

- ***Objective: Develop a low bandwidth low energy radio protocol.***
  - Implemented basic radio protocol for system testing and design.
  - Experimenting with different radio protocol designs for minimizing packet collisions and radio power consumption.
  - Started to port the basic Atmel mesh network stack and protocol for comparison of efficiency.
  - Began development on a system level analytical tool for measuring performance characteristics for radio protocol design.
  - Added small LCD display to help better aid debugging efforts during system development of firmware.
- ***Objective: Improve firmware architecture.***
  - Finished basic firmware functionality with new layer abstractions.
  - Completed increasing firmware modularity for driver/sensor abstraction.
- ***Objective: Create a fully assembled and functionally complete prototype board.***
  - Created revision 3 electrical prototype boards for development. Minor modifications and enhancements were made to optimize interfaces with physical components.
  - Received first fully assembled prototype boards from Gold Phoenix PCB.
  - Revision 3 prototype boards were functionally successful for all desired development purposes.



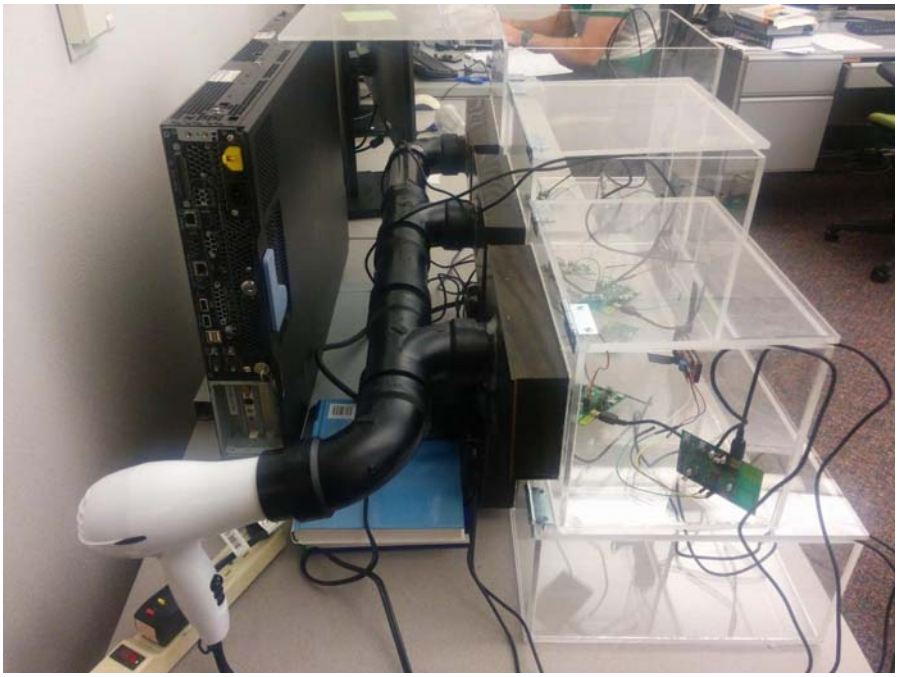
Fully Populated Prototype Board Revision 3

- ***Objective: Optimize firmware for power efficiency and longevity.***
    - Continued to further optimize power states for sensors and other physical components.
    - Began experimenting with energy harvesting via small wind turbines to prolong battery longevity.
    - Experimented with energy harvesting of ambient wireless signals, but was found to be inadequate for power needs.
    - Explored variable opening and closing positions for automated louvers as possible power saving enhancement as well as greater fidelity of control form temperature zones. More data is needed for a conclusive result.
- ***Objective: Develop temperature and pressure algorithms for system control.***
    - Successfully implemented generic temperature balancing algorithm.
    - Continuing to further enhance temperature algorithm to try and minimize automated louver movement needed for zone balancing.
    - Started to develop pressure detection algorithms for protecting HVAC coils when cooling.
    - Verified basic system functionally in simulated house environment to validate system concept.
- ***Objective: Research system extensions and other possible system applications.***
    - Beginning to research possible extensions such as air flow CFM measurements using small wind turbines ass additional safeguard against icing HVAC coils.
    - Explored the applications of including an optional booster fan at the register level in conjunction with a louvered system to help better regulate a zone's temperature.

Mechanical:

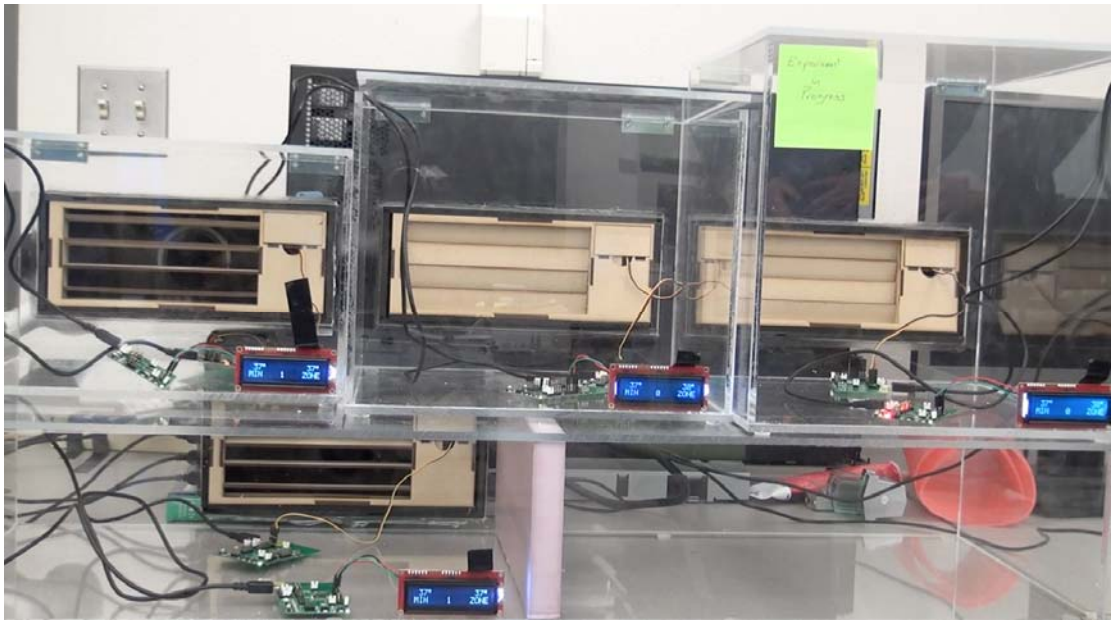
- ***Objective: Create a prototype environment for system level testing.***
    - Created a simplified venting system driven by a hair driver to simulate

HVAC heating cycles.



Ventilation Setup for Simulating HVAC Heating Cycles

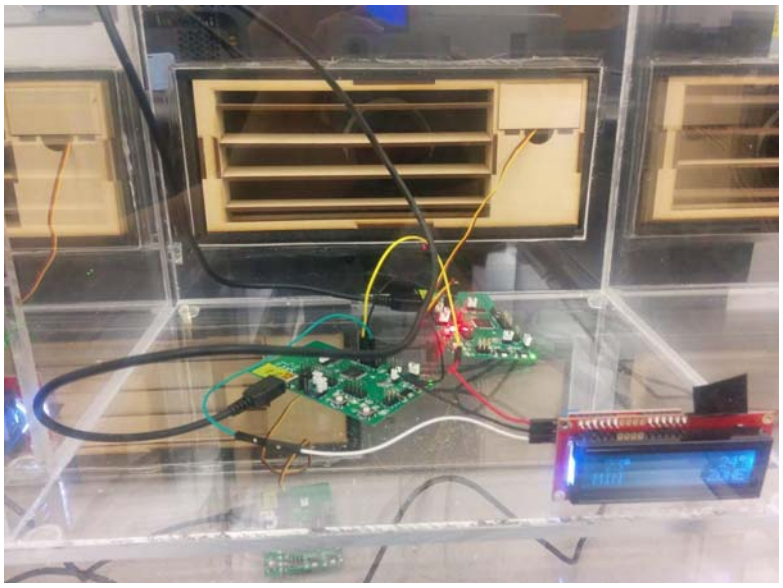
- Designed a small scale testing chamber for system level testing of HVAC heating cycles.



Testing Chamber for System Level Debug and Data Metrics

- ***Objective: Improve register prototype design to be closer to product dimensions.***
  - Further condensed prototype register to match desired product

dimensions. This meant condensing the height to 1” and redesigning the louvered mechanical system.



New Thin Prototype Register with Zone/Register Controllers and Debug LCD

2. Summary of budget expenditures for the period just completed (include project burn rate):

PI summer salary	$14,538	$0	100%
Student salary	$16,424	$12,279	25%
Fringe	$4,733	$84	98%
OE	$8,304	$4,653	44%
Travel:	$1,798	$1,798	0%
Total	$45,800	$18,815	$29,984

3. Numbers of faculty and student participation resulting from the funding, including internships: 6

Gang-Ryung Uh – PI
Kyle Schwab (Graduate Research Assistant) – Partially supported by HERC as a RA
Jared Law (Graduate Teaching Assistant) – Partially supported by CS
Gregory Cook (Graduate Teaching Assistant) – Partially supported by HERC and CS
Kyle Hoff (Undergraduate Research Assistant) – Partially supported by HERC
Adam Carrillo (Undergraduate Research Assistant) – Partially supported by HERC

4. List patents, copyrights, plant variety protection certificates received or pending:

- Provisional patent for “SAVE**:** Self Organizing Air Vent” is already filed - U.S. Patent Pending – 61/835,276.

- Recognition of the Boise State University team for being selected as a runner-up for the Business Venture Challenge at UKC 2013

5. List technology licenses signed and start-up businesses created:

   None.

6. Status of private/industry partnerships (include enough information to judge level of engagement):

   - The SAVE project interfaced with local HVAC manufacturer Marty Artis of Famco for guidance and possible joint opportunities. Famco expressed an interest in adapting the system as a residential performance measurement tool or commercial applications. We received great feedback, where their is a great opportunity for the SAVE system to tackle a challenging task of avoiding icing of HVAC coils.

7. Any other pertinent information that will indicate to the council that the project is meeting satisfactory progress.

Completed as the date of 05/30/2014 →

Tasks	1st quarter 7/1/13-9/30/13	2nd quarter 10/1/13-12/31/13	3rd quarter 1/1/14-3/31/14	4th quarter 4/1/14-6/30/14
Electronic prototype				
firmware development				
mechanical prototype				
testing and benchmarking				
patent preparation & filing				
project demonstration				
HVAC trade show				

Our current items of focus for development are:

- **Preventing HVAC coils from icing –** After several meetings with Famco a challenge that was presented to our team was preserving the integrity of the HVAC coils from icing. The SAVE system has already been developed with this problem in mind, but it will be very important for the SAVE system to mitigate this issue particularly. Our development has since shifted towards building a robust pressure detection algorithm to reduce the possibility of icing the coils. This also presents an opportunity for SAVE system growth as this is a problem that is commonly found in residential cooling systems. The SAVE system with enhanced pressure detection algorithms could report or alarm users of conditions that would cause the HVAC coils to ice.

- **Power management and battery longevity –** After our preliminary testing it has become apparent that we must continue to improve and develop on our low power, low bandwidth radio protocol design. This has started the creation of a new radio protocol analytical tool that will allow us to debug and develop our radio protocol design at a very high level, allowing us to capture an abundance of performance related data.

Ethernet Connector Board to be used

- **Micro wind turbine –** The SAVE system has heavily began to look into uses of micro wind turbines which would be able to provide a couple of benefits to the project. Firstly, it could be used as a source of power generation to help prolong the battery life through the use of energy harvesting. Secondly, it can assist with detecting air flow CFM to help further detect possible conditions indicating or leading to the icing of the HVAC coils.

Experimental Micro Wind Turbines to be used